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TERRESTRIAL MAGNETISM.—*A consistent theory of the origin of the Earth's magnetic field.*[1] L. A. BAUER, Department of Terrestrial Magnetism, Carnegie Institution of Washington.

Various investigations by well-known physicists have established the fact that electricity is an essential and possibly the only constituent of matter. Negative electrons can be obtained from practically any form of matter, by heating, by the action of ultraviolet light, by chemical means, and perhaps also by the application of suitable mechanical forces; they are thus proved to be a universal constituent of matter. Matter electrically neutral is supposed to contain equal amounts of positive and negative electricity. We may regard the Earth as a great reservoir of electricity, the two opposite total charges being apparently very nearly balanced. If it turns out that owing to some cause the one kind of elemental charge is, on the average, farther from the center of the Earth than the opposite kind, then because of this difference in distance and of the rotation of the charges with the Earth there will result a magnetic field perhaps of sufficient strength, to be detected by magnetic observations on the surface of the Earth.

Sutherland (1900–'03)[2] probably first advanced the idea that the Earth's magnetic field may be caused by the rotation with the Earth of two opposite and equal electric charges distributed thru the Earth and supposed to be contained within two concentric spheres whose radii differ by an amount which he found to be of the order of the radius of an ordinary molecule. Previously, however, Schuster (1891 and 1892) and Lord Kelvin (1892) had

[1] Presented before the Philosophical Society of Washington, December 7, 1912; for fuller publication see Terrestrial Magnetism, Vol. **18**, 1913.

[2] Sutherland, William, Terrestrial Magnetism, first in vol. **5**, 1900, p. 73, and later, in improved form, in vol. **8**, 1903, p. 49; see also same journal, vol. **9**, p. 167, and **13**, p. 155.

raised the question as to whether the magnetism of the Earth and celestial bodies, in general, may not be connected in some manner with the fact of their rotation.[3] J. J. Thomson had also pointed out in 1894[4] that if atoms possess a specific attraction for the two electricities—attracting one kind slightly more than the other—then a large rotating body ought to produce a magnetic field.

Sutherland's hypothesis avoids the difficulties pointed out by Rowland[5] in 1879 as also some of those advanced in connection with other theories. Unfortunately, however, it thus far admits of no conclusive proof, chiefly for the reason that it leads to an expression for the magnetic potential precisely the same, as far as effects on or above the Earth's surface are concerned, whether the magnetic field be due to an elemental magnet at the center of the Earth, or to a uniformly magnetized sphere, or to an appropriate system of electric currents imbedded in the Earth, or to a rotating electrically charged sphere such as Sutherland supposed, or to a combination of these causes. Mathematically the magnetic fields ascribed to these various, distinct causes can not be differentiated from one another.

If the supposed electrical distribution really exists within the Earth, then it may be that, because of gravitational force, or of some other central force, the elemental charges tend to arrange themselves so that the "center of gravity" of one kind of electrical charge is, on the average, slightly nearer the Earth's center than that of the other kind, or, still better, so that the mean volume density of the positive body charge is slightly different from that of the negative. This being assumed, it seems rational to inquire whether, during the Earth's rotation there may occur some alteration in the mean densities of the opposite charges or in the radial separation, or in both, to be attributed perhaps to some action of the Earth's centrifugal force. Though the ques-

[3] The reader desiring to familiarize himself with the difficulties attaching to the chief hypotheses advanced is advised to read the following suggestive papers: Schuster, A., A critical examination of the possible causes of terrestrial magnetism, Proc. Phys. Soc. London, **24**: pt. III, p. 127; and Swann, W. F. G., The Earth's magnetic field, Phil. Mag., **24**: 80. 1912.

[4] Thomson, J. J., On the electricity of drops, Phil. Mag., [5], **37**: 358. 1904.

[5] Rowland, Physical papers, p. 182, Johns Hopkins Press, Baltimore, 1902.

tion has been raised whether electrons can be acted upon by a mechanical force, such as centrifugal force, it has not yet been experimentally settled in the laboratory, probably because of lack of required sensibility of the instrumental appliances used, and because of the limitations set upon the size and speed of rotation of the body which can be experimented upon.[6] Possibly in the case of the Earth we have a body of sufficient size and angular velocity to obtain appreciable effects.

The rotation of the supposed electric charges with the Earth, if distributed symmetrically about the Earth's center as Sutherland premised, will result, as already pointed out, simply in producing the so-called "uniform magnetic field" whose equivalent intensity of magnetization per unit of volume is constant thruout the Earth's interior; this, however, we know not to be the case. The hope of revealing the cause of the Earth's magnetic field apparently centers in the discovery of the cause which makes the actual field depart from the uniform or simple type. Hence, *the keynote of our line of investigation is the study of the variations*—in this particular instance the geographical variations of the characteristic constants defining the Earth's magnetic field.

The most important fact of terrestrial magnetism at this juncture is one which I found in 1901,[7] viz., that "the value of the magnetic moment is a maximum for the equatorial belt, and decreases steadily in both hemispheres with departure from the belt." This law may be formulated mathematically thus: Let X be the component of the Earth's total magnetic intensity directed along a meridian, positive northward, and Z be the vertical component directed positive downwards; if D be the magnetic

[6] Cf. Nichols, E. F., Die Möglichkeit einer durch zentrifugale Beschleunigung erzeugten elektromotorischen Kraft. Phys. Zs. 7 Jhrg. No. 18, pp. 640–642. Lebedew, P., Ueber die magnetische Fernwirkung rotierender Körper, Ann, d. Phys. 1912, No. 14, 840–848. (This was this brilliant investigator's last work, he having died before the appearance of his paper. He examined whether the Earth's total magnetic field could be referred to effects attributable to centrifugal action and supposed that the negative electron would be the one shoved outwards by centrifugal action. He tested the question experimentally but reached no definite results for the reasons already stated above.)

[7] Terr. Mag., **6**: 22. 1901 and later investigations in same journal, **17**: 85. 1912 and pp. 115–118.

declination, I, the dip, and H, the horizontal intensity, then $X = H \cos D$, and $Z = H \tan I$. Obtain X and Z with the aid of magnetic charts at equidistant points along parallels of latitude, say every 10° apart in longitude; thus there will be 36 values of X and of Z for each parallel covered by the charts, 60 N to 60 S, from which the average values X_a and Z_a for each parallel may be obtained. By operating with the average values we eliminate the portion of the Earth's magnetic field asymmetrical about the axis of rotation and if we, furthermore, combine the values for corresponding parallels N and S, the asymmetrical portion about the equator is also eliminated. The values of X_a and Z_a finally obtained apply then only to the portion of the Earth's magnetic field symmetrical about both the axis of rotation and the equator; they will be found given below as derived with the aid of all the magnetic charts at present available (Sabine's for 1840–45; Creak's 1880, and Neumayer's 1885).

VALUES OF THE RECTANGULAR MAGNETIC COMPONENTS X_a AND Z_a AND OF THE CHARACTERISTIC FUNCTIONS, IN C.G.S. UNITS, FOR APPROXIMATELY THE YEAR 1869.

PARALLEL	OBSERVED VALUES				OBSERVED − COMPUTED VALUES			
	X_a	Z_a	$f_x(u)$	$f_z(u)$	ΔX_a	ΔZ_a	$\Delta f_x(u)$	$\Delta f_z(u)$
60° N & S...	0.1437	0.5374	0.2874	0.3103	−0.0030	+0.0013	−0.0005	−0.0003
50° N & S...	0.1891	0.4855	0.2942	0.3170	− 6	− 8	+ 7	+ 3
40° N & S...	0.2317	0.4176	0.3025	0.3248	+ 7	− 14	− 2	0
30° N & S...	0.2718	0.3340	0.3140	0.3340	+ 12	− 1	− 3	+ 1
20° N & S...	0.3064	0.2340	0.3261	0.3420	+ 13	+ 9	+ 4	− 4
10° N & S...	0.3291	0.1210	0.3343	0.3486	− 2	+ 12	+ 1	+ 1
Equator....	0.3363	0.0000	0.3364	*0.3510	†− 18	†0	− †9	+ †3

* Obtained graphically with the aid of values 5° N and S.
† Weight ½.

In whatever manner the magnetic field here considered may have originated, we may write:

$$X_a = f_x(u) \cdot \sin u \qquad Z_a = 2 f_z(u) \cdot \cos u \qquad (1)$$

where u is the colatitude of the parallel considered and $f_x(u)$. $f_z(u)$ are functions of u, termed the "characteristic functions," as they contain the secrets of the origin of the field. Thus for a simple uniform magnetic field (i.e., one for which the magnetic

force within the sphere is constant in amount and in direction, parallel to axis of rotation in the present instance), $f_x(u) = f_z(u) = \frac{4}{3}\pi\mu$ = constant throughout the Earth, μ being the equivalent intensity of magnetization per unit of volume. The observed values of the characteristic functions as derived with the aid of (1) are given in the third and fourth columns of the table. It is seen that not only are the two functions not equal to each other for the same parallel, but, what is more important, in both instances the values increase systematically towards the equator. The equivalent value of μ is found to be, in C. G. S. units, about 0.070 for parallel 60° and 0.082 for the equator, showing an increase of about 17 per cent—certainly an appreciable quantity. The law of increase in the values of the characteristic functions furnishes a definite criterion for testing the validity or sufficiency of theories of the Earth's magnetism; when applied, it is found that none of the theories thus far advanced account for the equatorial increase in intensity of magnetization, some in fact giving instead a decrease. The hypothesis that the increased magnetization may be due to increased strength of that which produces the primary field—be it increased actual magnetization or increased strength of electric current or of rotating charges—at once occurs to one's mind, and a first examination shows that it is an effect similar to that probably to be expected if attributable to the Earth's centrifugal force.[8]

It is not possible here to give all the mathematical steps involved; suffice it to say that the analysis at present has been made for possible potential systems both below and above the Earth's surface, which by their combination may be considered to produce the magnetic field observed on the Earth's surface. Instead of supposing a spherical distribution of the two opposite body charges, as did Sutherland, we have taken a spheroidal distribution owing to the supposed action of the Earth's centrifugal force. The expansion has been carried thus far to include the fifth degree zonal harmonic. The differences between the observed values of the rectangular components and of the characteristic functions and the computed values, resulting from the analysis, will be found in the above table.

[8] Terr. Mag. **17**: 138. 1912.

It is found that in order to accord with the most obvious fact —that the north-seeking end of the magnetic needle dips in the Northern Hemisphere—*the negative elemental charges within the Earth must, on the average, be the farther away from the Earth's center*, i.e., be distributed thru a slightly larger sphere than the one supposed to contain the positive charges. For the portion of the Earth's magnetic field supposed to arise from the rotation with the Earth of the electric charges in the atmosphere, the chief fact of observation is that the north-seeking end of the magnetic needle points above the horizon in the Northern Hemisphere. To comply with this fact, it is found that, *on the average, the negative elemental charges in the atmosphere must also be the farther away from the Earth's center than are the positive ones.*

That the same kind of electric distribution suffices to produce both the Earth's internal and external magnetic systems is considered one of the chief gains. Theories, heretofore, have either stopped with a consideration of the internal system alone or have involved contrary or independent hypotheses for both systems. Thus, if the systems are referred to electric currents for the internal system, then the currents would have to pass around the Earth from east to west, hence contrary to the Earth's rotation, whereas, for the external system, they would have to go from west to east, hence in the same direction as that of rotation.

Taking the average atomic weight of the Earth's substance, in round numbers as 50, it is found that, if the radii of the two spheres supposed initially to contain the opposite and equal body charges of the Earth differ by only 0.4×10^{-8} cm., i.e., by about four-tenths of the radius of an ordinary molecule, a magnetic field of the required strength results in the manner supposed.[9] The corresponding quantity for the effects ascribed in this paper to the supposed action of the Earth's centrifugal force is on the order of 0.01×10^{-8} cm. The present adalysis resolves the so-called Gaussian constants, generally regarded as the elements or ultimate constants of the Earth's magnetic field, into physically interpretable constituents.

[9] The energy necessary to remove a negative electron from an atom indicates that the positive and negative charges are about 10^{-8} cm. apart in the atom and that the molecules may be regarded as having a definite volume of radius of about 10^{-8} cm. H. A. Wilson: Structure of Atoms, Science, N. S. **35**: 511, 1912.

Were there time, some further interesting deductions might be given, as also some results of a preliminary study of the asymmetrical portions of the Earth's magnetic field, not considered in this paper. In conclusion, let it be emphasized that no claim is made that the only possible mechanical description of the phenomena has been given. It is quite possible to replace the fundamental concept by some other; however, there still remains to be found some adequate explanation for the disturbance effects studied in this paper and provisionally referred to the Earth's centrifugal action. The main purpose of the investigation is to discover a working hypothesis for guidance in the magnetic operations at present in progress, and to obtain clues as to any possible additional data which may be required beyond those usually obtained in magnetic surveys.

PHYSICS.—*A micropyrometer.* GEORGE K. BURGESS, Bureau of Standards.

Some time ago, a method was described[1] suitable for the rapid estimation of the melting points of minute specimens—as fine as 0.001 mgm. or less. A microscope and an optical pyrometer were sighted through a window of mica, or of plate glass in case of melts in vacuo, simultaneously on an enclosed metallic strip such as platinum, heated electrically and upon which was placed the specimen to be melted.

Evidently this apparatus may be simplified by combining microscope and pyrometer into a single instrument, thus permitting a single observer to watch the melting and measure its temperature. This is effected by mounting within the Huyghens eye-piece of an ordinary microscope a small incandescent lamp, which is in series with a rheostat and ammeter. The tip of the filament of the lamp is set to the same brightness as the platinum strip viewed from above at the instant of melting of the metallic or other specimen on which the microscope is focussed. The eye of the observer therefore sees the specimen, the platinum strip and the lamp filament all in focus at once and the current thru the

[1] Burgess, G. K., Melting points of the iron group elements by a new radiation method. Bulletin Bureau of Standards, **3**: 345. 1907.

lamp is taken as a measure of the temperature of the strip as in the Morse or Holborn-Kurlbaum pyrometer. In practice, the observer with one hand raises the temperature of the platinum strip by increasing the electric current thru it by means of a fine-step rheostat and with the other hand adjusts the rheostat in the pyrometer circuit so as to continuously match in brightness the lamp filament and platinum strip. The eye-piece is furnished with a piece of monochromatic glass such as Jena red filter no. F 4512. For temperatures above which the lamp should not be burned, say 1400°C., an absorption glass is placed between the microscope objective and furnace window. The inside of the metallic container or furnace should be blackened to prevent undesirable reflections of light from the walls.

The calibration of the pyrometer as sighted upon the platinum strip in the furnace may be made in two ways. The first, which was the only method available when the earlier form of this apparatus was brought out, due to the dearth of well known fixed points in the temperature range studied, consists in calibrating the pyrometer in the customary manner and then applying the corrections at the temperatures of melting, for the emissivity of platinum, furnace atmosphere and window, and for the surface tension of the melting specimens when necessary.

The second method, which appears to be the more accurate and also more convenient, consists in observing the lamp currents at the known melting points of two or more pure substances such as gold, nickel, cobalt and palladium, and from the equation expressing the relation between temperature and current in lamp, the temperature of melting of any specimen may be computed. For not too great temperature intervals, the equation $\log c = a + b \log t$ may be used which permits calibration with two fixed points only.

This second method of calibration has the further advantage that, for materials of approximately the same general properties, the error of method is eliminated. Thus in the case of metals which alloy with platinum, the effects of alloying conductivity and of surface tension enter into the calibration as well as into the determination of the unknown melting point, so that any out-

standing error will be but a residual one. In the case of substances of dissimilar properties such as salts and metals, this apparatus must be used with caution, for, in general, a calibration made in terms of the metal melting points, for example, will not serve for the exact determination of the melting points of salts.

The precision of the method is dependent mainly upon the character of the melting of the substances observed. With metals such as gold and nickel, which melt very sharply, a precision of 1° or 2° C. is obtainable.

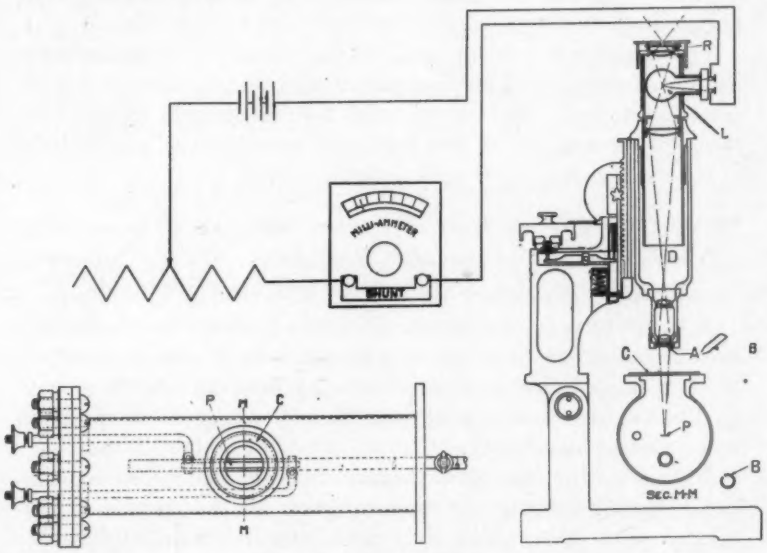

Fig. 1. A Micropyrometer

The apparatus as constructed at the Bureau of Standards, largely from suggestions due to Messrs. Crowe and Foote of this Bureau, is shown in figure 1; in which L is the pyrometer lamp, R the monochromatic glass, A the absorption glass, P the platinum strip carrying the specimen, C the furnace window, B an air blast for cooling the furnace. The microscope has a Bausch and Lomb 48 mm. single achromatic lens and 6.4 × eye-piece and gives

sufficiently good definition and magnification, and a large enough field of view for melting point observations. The working distance of the objective may be increased, if desired, by the device employed by Robin[2] of inserting a biconcave lens at *D* slightly back of the focus of the objective. This necessitates lengthening considerably the draw tube and reduces the area sighted upon.

The micropyrometer may, of course, be used for the estimation of temperatures of incandescent surfaces simultaneously with their examination, and thus becomes a useful instrument in metallographic and microchemical and physical investigations at high temperatures.

The apparatus is being used at the Bureau of Standards for the determination of melting points and emissivities of the refractory elements and alloys, and the author will be glad to receive pure samples (a few hundredths milligram), particularly of the rarer elements for such determinations.

PHYSICS.—*The constants of spectral radiation of a uniformly heated enclosure or so-called black body.* W. W. COBLENTZ, To appear in The Bulletin of the Bureau of Standards.

In previous communications (Physical Review, 1910 and 1911) accounts were given of the progress made in the investigation of the constants involved in the formulas, proposed by Wien and by Planck, for expressing the partition of energy in the spectrum of a so-called black body.

In view of the fact that the great mass of theoretical speculations seemed entirely out of proportion to the slender experimental data upon which they were based, it seemed desirable to obtain an extensive series of observations under all sorts of conditions, leaving the exact computation of the results until the very last, and then computing all the data on a uniform basis. From the beginning of the work, four years ago, attention was called to the fact that the Wien equation does not fit the observed spectral energy curves, and in later communications, the computations were made on the basis of the Planck equa-

[2] F. Robin, Microscope à longue portée, etc. Bull. de la Société d'Encouragement **118**: 204. 1912.

tion, introducing all the known correction factors which can effect the observed spectral energy curves. These factors are (1) corrections for the selective reflection of the silver mirrors, the fluorite prism, and the fluorite window which covers the vacuum bolometer; and (2) the corrections for the variation in reflecting power with angle of incidence upon the silver mirrors and upon the fluorite prism.

In the isothermal spectral energy curves the position, λ_{max}, of the maximum emission, E_{max}, is computed by taking the wave-lengths, λ_1 and λ_2 corresponding to equal emissivities $E_1 = E_2$, on the assumption that the observed energy curve fits the Planck equation:

$$E_\lambda = C_1 \lambda^{-\alpha} (e^{c_2/\lambda T} - 1)^{-1} \tag{1}$$

from which follows

$$\lambda_{max} = \frac{\alpha(\log\lambda_2 - \log\lambda_1)\lambda_1\lambda_2}{\alpha^1 (\lambda_2 - \lambda_1) \log e} - \frac{\lambda_1\lambda_2 [\log (1 - e^{-c_2/\lambda_1 T}) - \log (1 - e^{-c_2/\lambda_2 T})]}{\alpha^1 (\lambda_2 - \lambda_1) \log e} \tag{2}$$

The second term in this equation can usually be abbreviated since terms involving λ_1 are usually negligible. For values of λ_2 which are less than about 4μ the term $\log (1 - e^{-c_2/\lambda_2 T})$ may be expanded into a series and (by dropping all terms but the first) may be used in the form $-e^{-c_2/\lambda_2 T} \log e$.

In this equation $\alpha = 5$, $\alpha^1 = 4.9651$ and $c_2 = \alpha^1 \lambda_m T$. For computing the second term correction factors to λ_m, the value of $c_2 = 14{,}500$ was used. However a variation of 100 units in c_2 (e.g., $c_2 = 14{,}600$) would change the mean value of λ_{max} by only 0.0005μ, which is negligible.

For computing the constant c_2 from an iso·hromatic energy curve, at any wave-length, λ, Planck's equation is used in the following form:

$$c_2 = \frac{(\log E_2 - \log E_1)\, \lambda T_1 T_2}{\log e\, (T_2 - T_1)} - \frac{(e^{-c_2/\lambda T_2} - e^{-c_2/\lambda T_1})\, \lambda T_1 T_2}{T_2 - T_1} \tag{3}$$

where E_1 and E_2 refer to the emissivities corresponding to the temperatures T_1 and T_2 respectively. In this equation the terms $\log (1 - e^{-c_2/\lambda T_1}$, etc., were expanded into a series and only the

first term $(1-e^{-c_2/\lambda T_1})$ log e, etc.) is used. As in equation (2) an approximate value of $c_2 = 14{,}500$ is used in applying the second term correction. For wave-lengths up to $1\,\mu$ this correction term is small being only 2.1 and 4.3 for temperatures intervals $(T_2 - T_1)$ of 363° and 623°, respectively, when using $T_1 = 1450$°C. However these corrections increase very rapidly with wave-length beyond $1\,\mu$ so that at $2\,\mu$, with the same temperature intervals just mentioned, the second term corrections to the values of c_2 amount to 168 and 227 respectively.

As already stated, it was deemed of greater importance to obtain experimental data than to spend the time discussing the bearing of the data at hand upon existing theories. From the data now at hand, this procedure seems amply justified. More than 180 isothermal energy curves have been obtained, and by actual count 75 to 80 per cent of the reliable sets of these curves are found to fit the Planck equation, within the experimental errors of observations. The numerical values of the constants are smaller than the older determinations of Paschen, and of Lummer and Pringsheim (and, for that matter the earlier values of the present data, obtained by a different system of computation, and not including all the correction factors for reflection). However, as will be shown in the complete paper, the data of previous observers are in agreement with present values, when computed on the same basis.[1]

The data now available were obtained with different fluorite prisms, water cooled shutters, air and vacuum bolometers, and thermocouples. The radiators were platinum-wound porcelain

[1] For example, Paschen's data, if computed by the present methods would give a value of $\lambda_m T = 2912$ and $c_2 = 14{,}460$. The data of Lummer and Pringsheim are wrong owing to an error in their calibration curve which amounts to 0.02μ for the region of the spectrum up to 2.5μ. This would decrease many of their values of λ_{max} by almost 1 per cent, and reduces their mean value to $\lambda_m T = 2930$. Their energy curves did not fit the Wien equation and since in the present research, radiators of their design were used under conditions which were similar to theirs, it is possible to recalculate their data by the present methods of computation. This gives a mean value of $\lambda_m T = 2911$ and $c_2 = 14{,}450$. If we exclude their last value of $\lambda_m T = 2814$, which is evidently not comparable with the rest, their mean value of $\lambda_m T = 2924$ and $c_2 = 14{,}500$. Considered as a whole, a fair estimate of the older data is $c_2 = 14{,}460$ to $14{,}500$.

tubes of the design used by Lummer and Pringsheim. Energy curves were obtained from these tubes before and after they were blackened with chromium and cobalt oxides. It was found that the percentage of the energy curves fitting the Planck equation was greatly increased when the radiators were blackened. There are still a few outstanding discrepancies which need further investigation. For example, the average value of c_2 for a given set of observations may be 0.2 to 0.5 per cent higher than a similar series made, under slightly different conditions, but using the same prism, which was flawless. Usually these fluctuations coincide with variations in humidity, but this is not sufficient to fully explain the matter. Again, when using a fluorite prism containing numerous flaws, which caused a conspicuous scattering of light, the energy curves appear to be distorted so that only 25 to 30 per cent of them fit the Planck equation, and the value of c_2 is extraordinarily high, being of the order of $c_2 = 14{,}700$. The data obtained in 1910 and in 1911, using a flawless prism, give an average value of $c_2 = 14{,}540$. Using the same prism, in 1912, the value of the constant is slightly lower, being of the order of $c_2 = 14{,}490$. Altho this difference of 0.3 to 0.4 per cent in the values of c_2 is systematic it is within the experimental errors of observation. It therefore appears that the weighted value of this constant will be found to be close to $c_2 = 14{,}500$; and $\lambda_m T = 2920$. This value of $c_2 = 14{,}500$ appears to be about 1 per cent higher than the preliminary results published by Warburg and his associates at the Reichsanstalt.

The constant, c_2, is of great importance in optical pyrometry, and heretofore owing to the absence of concordant data experimenters have used values ranging from $c_2 = 14{,}200$ to $c_2 = 14{,}600$. The value of the melting point of platinum, on the basis of the optical temperature scale, using $c_2 = 14{,}500$, was observed by Waidner and Burgess to be 1753°. The latest work on the gas temperature scale by Day and Sosman, extrapolating the thermoelectric scale from palladium, m. p. = 1549°2, gives a value of 1750° to 1755°, with a mean value of 1752°, for the melting point of platinum. A melting point of 1755° is equivalent to a value of $c_2 = 14{,}475$ which is close to the predominating values of this

constant as observed in the 9 sets of observations, aggregating 90 spectral energy curves which were obtained in 1912. While it is very gratifying to find that the new value of $c_2 = 14{,}500$ places the melting point of platinum within 1° or 2° of the observed values (which are uncertain by a similar amount), this coincidence is to be considered somewhat accidental.

Planck's theory of the mechanism involved in the production of "black" radiation admits of the computation of the value of the elementary electrical charge, e, by means of the constant of spectral radiation, b, ($\lambda_m T = 2920$) and the constant, σ, of total radiation. The recent determinations of the constant of total radiation, by Gerlach and by Puccianti give a value of $\sigma = 5.9 \times 10^{-12}$ watts per cm.^{2} per deg.^{4} Combining this with the value of $b = 0.2920$ cm. deg. gives a value of $e = 5.1 \times 10^{-10}$ E. S. U. This is considerably higher than the experimental value by Millikan, which is 4.777×10^{-10} E. S. U. While the time is still premature to attempt to harmonize the experimental value and the theoretical value as deduced from the radiation laws, it is of importance to notice that there are wide variations in the various determinations of the constant, σ, of total radiation. In future communications it is hoped to contribute values of σ, which are determined with some of the apparatus used in determining c_2.

Heretofore, the experimental work on the spectral energy curves was done in the winter time when the humidity was low. The season of low humidity being close at hand, it is purposed to observe several more series of energy curves, using other fluorite prisms, before publishing a more complete report. As matters now stand it seems highly desirable to put the complete optical path of the spectroradiometric apparatus and of the radiator in a vacuum in order to obtain the complete spectral energy curves free from the atmospheric absorption bands of water vapor, carbon dioxide, and oxygen.

METALLOGRAPHY.— *An improved vertical-illuminator.* FRED EUGENE WRIGHT, Geophysical Laboratory.

Of the two types of vertical-illuminators which are in current use on the metallographic microscope, the reflecting prism type furnishes the best illumination with low power objectives. With

high power objectives it is less satisfactory because the reflecting prism cuts off half of the rays from the objective and thus seriously impairs the resolving power and general efficiency of the optical system.[1] The second type of illumination with the Beck illuminator does not suffer from this defect as the light which is reflected from the thin glass plate passes, on its return after reflection from the metal surface, thru the glass plate itself on its way to the eye of the observer. The glass plate thus serves both to reflect and to transmit the light; the resulting intensity of illumination is, however, noticeably less than that obtained by the first method. For satisfactory work the glass plate should be plane and thin and the source of light so arranged that none of the rays reflected from the objective lens surfaces reach the eye of the observer, otherwise they cast a haze or fog over the entire field, thus reducing the contrasts and flooding the image with false light.

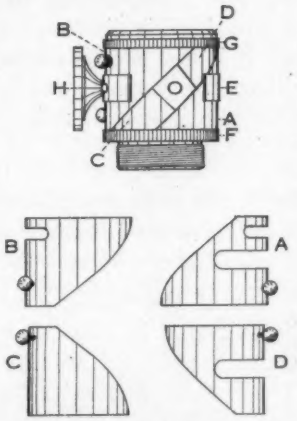

Fig. 1. Improved vertical illuminator

The device illustrated in figure 1 was constructed in the Geophysical Laboratory five or six years ago, to correct this defect and has been found so satisfactory and useful in practice that it is perhaps worthy of brief description. It enables the observer to produce an aperture of any desired size in any part of the field; he has thus control over the entire field and can eliminate any incident rays which would otherwise disturb the kind of illumination desired. He can moreover obtain rays of any desired obliquity of incidence and thus increase or decrease the apparent relief of the surface under observation.

The adjustable aperture is obtained by fitting to the ordinary vertical illuminator (Bausch and Lomb type) four cylindrical

[1] Carl Benedicks, Metallurgie **6**: 1–4. 1904.

segments *A*, *B*, *C*, *D* (two outer segments, *A*, *B*, and two inner segments, *C*, *D*) all of which fit into grooves cut into the supporting collars *F*, *G* of figure 1 and can be rotated by grasping the small knobs and sliding each segment in its track, thus increasing or decreasing the size of the diamond shaped aperture at 0 (fig. 1). The ring marked *E* can also be rotated and a triangular aperture obtained if desired. These segments can be made by a good mechanic without difficulty and are so simple both in construction and manipulation that further description is unnecessary. A movable iris diafram may also be used for the same purpose, but it is less effective because it does not allow the observer to change the shape as well as the position of the aperture and thus to obtain intense illumination without, at the same time, introducing false light.

BOTANY.—*Pseudannona, a new genus of Annonaceae from the Mascarene Islands; together with notes on Artabotrys uncinatus and its synonymy.* W. E. SAFFORD, Bureau of Plant Industry.

Among the Annonaceae of the island of Mauritius described by Lamarck in 1786 were three species referred by him to the genus Annona: *A. grandiflora*, *A. amplexicaulis*, and *A. uncinata*.[1] These were afterwards figured by Dunal in his monograph of the Annonaceae, the generic name assigned to them by Lamarck being retained for the first two species but the last being placed in the genus Unona, under the name *U. uncinata*. Dunal's plates show at a glance that the first two plants above named, which have separate carpels, each containing several seeds, cannot possibly belong to the genus Annona, the fruit of which is a syncarpium composed of a number of 1-seeded carpels fused together in a consolidated mass; and *Unona uncinata* (Lamarck) Dunal has been made the type of a new genus, *Artabotrys*, one of the distinguishing characteristics of which is the peculiar hook-like peduncles of the flower, which at length serve as a support for the fruit.

That Lamarck's *Anona grandiflora* and *A. amplexicaulis* do not belong to the genus to which they were assigned was recog-

[1] Lamk. Encycl. Bot. 2: 126, 127. 1786.

nized by Baillon, who placed them in the genus Xylopia, in a section by themselves, which he called Pseudanona (see Adansonia **4**: 142. 1864); but in studying the genus Xylopia the present writer has become convinced that these two Mauritian plants cannot possibly be regarded as congeneric with the West Indian *Xylopia muricata*, the type of the genus as established by Linnaeus,[2] and it is therefore proposed to segregate them by raising Baillon's section to generic rank under the name of *Pseudannona*. The genus may be described as follows.

Pseudannona (Baillon) gen. nov.

Calyx gamosepalous, subtriangular or 3-lobed. Corolla composed of 6 petals in 2 series, all of which are valvate, the outer 3 longer and broader than the inner and subspatulate in form, the inner more or less triquetrous especially near the apex. Receptacle (torus) domeshaped, with a crater-like depression at the center from which issue the styles of the sunken ovaries. Ovaries distinct, each terminating in a slender style which is recurved near the extremity where it is provided with numerous stigmatic papillae. Ovules several, biseriate, not superimposed as in the genus Xylopia. Stamens numerous borne on the outer slope of the torus and forming a crowded mass surrounding the central cluster of carpels; filaments stout, bearing on their back a pair of linear parallel pollen sacs opening extrorsely by a longitudinal slit and surmounted by the broadened connective. Fruit a cluster of distinct several-seeded carpels borne on the hardened receptacle, or torus, not a syncarpium composed of many 1-seeded carpels fused together as in the genus Annona. Climbing or erect shrubs with solitary 1-flowered peduncles indigenous to the islands of Mauritius and Madagascar.

Thus far but two species can with certainty be referred to this genus, a third species, from the forests of Mauritius is like *P. grandiflora*, a climbing shrub and has been described as *Anona pyriformis* Bojer. Tho the latter cannot possibly belong to the genus Annona it is doubtful whether it should be assigned to the present genus, owing to its broad inner petals which resemble

[2] Linnaeus. Syst. Nat. **2**: 1250, 10 ed. 1759.

the outer in form. Its generic affinities cannot be established owing to the absence of fruit. The following are the species thus far known belonging to the genus Pseudannona.

1. **Pseudannona amplexicaulis** (Lamk.) comb. nov. Type of the genus.
   Anona amplexicaulis Lamk., Encycl. Bot. **2**: 127. 1786; Dunal, Monogr. Anon. 76, pl. 7. 1817; DC. Syst. **1**: 475. 1818; Prodr. **1**: 86. 1824; Bojer, Hort. Maurit. **5**. 1837; Baker, Fl. Maurit & Seych. **3**. 1877.
   Xylopia amplexicaulis Baill., Adansonia **4**: 142. 1864; Hist. Pl. **1**: 226. 1867.
2. **Pseudannona grandiflora** (Lamk.) comb. nov.
   Anona grandiflora Lamk., Encycl. Bot. **2**: 126. 1786; Dunal, Monogr. Anon. 75, pl. 6 & pl. 6a. 1817; DC. Syst. **1**: 475. 1818; Prodr. **1**: 86. 1824; Bojer, Hort. Maurit. 5. 1837; Baker, Gl. Maurit. & Seych. 3. 1877.
   Xylopia Lamarckii Baill., Adansonia **4**: 142. 1864; Hist. Pl. **1**: 227. 1867.

NOTES ON ARTABOTRYS UNCINATUS

This plant, which is one of the sources of the perfume called ylangylang, is of East Indian origin, but is now cultivated in many tropical countries for the sake of its fragrant flowers. Unlike the true ylangylang (*Canangium odoratum* (Lamb.) King) it is a climbing shrub instead of a tree; the connective of its stamens is broadly expanded instead of being produced into a long tapering point; and its one-carpelled fruits contain 2 seeds each arranged side-by-side instead of several superimposed in a series. The following is a translation of Lamarck's original description, under the botanical name *Anona uncinata*, or "corossol with hooks."

This corossol is remarkable for the singular hooks which the floral peduncles bear, and which almost resemble the stipulary spines of Hugonia [a genus of Linaceae occurring in the tropics of the Eastern Hemisphere, some of the species of which have hooked axillary peduncles]. Its branches are woody, terete, glabrous, and somewhat zigzag

in form, bearing alternate, lanceolate or oblong-lanceolate, acuminate leaves, glabrous on both sides, glossy, and short-petioled, with blades 5 to 7 inches long by almost 2 inches broad. The pedicels are one-flowered, 6 lines long, and each borne on a special inclined hook almost curved into a spiral, somewhat flattened, and usually opposite a leaf. The flower is rather large and has a calyx with 3 ovate-acute divisions much shorter than the corolla; 6 ovate-lanceolate petals, brownish red on the upper part, with broad claws at the base, tomentose, concave within, and constricted between the claw and the blade. The 3 outer petals are slightly larger than the others. The fruits [ripe carpels] are ovoid-globose, of the size of a walnut enclosed in its hull, with the surface smooth and slightly punctate, and containing oblong seeds, few in number, arranged longitudinally as in *Anona grandiflora* [*Pseudannona grandiflora* (Lamk.) Safford].

The following is the synonymy of this species.

Artabotrys uncinata (Lamk.) comb. nov.

Anona uncinatus Lamk., Encycl. Bot. **2**: 127. 1786.

Unona uncinata Dunal, Monogr. Anon. 105, pl. 12, & pl. 12a. 1817; DC. syst. **1**: 490. 1818; Prodr. **1**: 90. 1824.

Uvaria uncata Loureiro, Fl. Cochinch. **1**: 349. 1790; Roxb., Fl. Ind. **2**: 666. 1832.

Artabotrys odoratissimus R. Br. in Bot. Reg., pl. 423. 1819; Hooker f. & Thoms., Fl. Ind. 128.128. 1855; Benth., Fl. Hongkong, 10. 1861; Hooker f., Fl., Brit. Ind. **1**: 54. 1872; Kurz, For. Fl. Burm. **1**: 31. 31. 1877; Baker, Fl. Maurit. & Seychelles 4. 1877; King, Anon. Brit. Ind. 44. pl. 55. 1893.

Uvaria odoratissima Roxb., Fl. Ind. **2**: 666. 1832.

From the above synonymy it appears that Lamarck's specific name (*uncinata*) was recognized by Dunal and De Candolle. Its original publication preceded that of Loureiro (*uncata*) by four years. In establishing the genus Artabotrys the first specific name of the type was disregarded by Mr. Brown, tho quoted by him in his synonymy, and the manuscript name of Roxburgh was adopted instead. According to the accepted rules of priority the first specific name must be used, and the plant must be designated as *Artabotrys uncinatus*.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

TERRESTRIAL MAGNETISM.—*Researches of the Department of Terrestrial Magnetism: Land magnetic observations, 1905–1910.* L. A. BAUER, Carnegie Institution of Washington. Publication No. 175. Pp. vi + 185, with 10 plates. 1912.

This publication contains the results of all magnetic observations made on land by the Department of Terrestrial Magnetism from the beginning of its observational work in February, 1905, to the end of 1910. Descriptions of the types of instruments used are given. The discussion of the general methods of the magnetic and astronomical field work include, besides the general detail of selection and occupation of stations, specimens of field records, computations, and determinations of constants and corrections. However carefully constructed, various instruments give results differing by small more or less constant amounts and hence arises the necessity of adopting some standard of reference. The Department has made for this purpose extensive intercomparisons of instruments at Washington, in the field, and at many magnetic observatories thruout the world; with the data thus obtained it has been possible to reduce the magnetic results for the region covered in the publication to magnetic standards within an error in general in the order of the error of observation. The intercomparisons of the provisional magnetic standards adopted with the standards of twelve observatories in the northern hemisphere and four in the southern hemisphere are given, as also the indirect results of observations by other organizations at seven additional magnetic observatories in the northern hemisphere; these show that the provisional standards adopted are very close to international standards, at least so far as all practical requirements of a general magnetic survey of the earth are concerned. The

corrections to these standards for the various instruments used are given in detail. The results are summarized under the main geographical divisions as follows: Africa, 386 stations; Asia, 308 stations; Australia, 10 stations; Europe, 36 stations; North America, 328 stations; South America, 111 stations; Islands, Atlantic Ocean, 68 stations, Islands, Pacific Ocean, 51 stations. The total number of stations is 1298; with reoccupations the total is 1391. The Table of Results contains for each station the geographical latitude, longitude, date of observation, the observed values of magnetic declination, inclination, and horizontal intensity, the local mean times to the nearest one-tenth hour for each element, the instruments used, and the observer. Accounts of some of the expeditions are given with illustrations primarily to show in a general way, the character of the field work and some of its difficulties. The last section of the volume is devoted to descriptions of stations arranged under the same geographical divisions adopted in the Table of Results.

J. A. FLEMING.

PHYSICS.—*The present status of the temperature scale.* GEORGE K. BURGESS. Eighth International Congress of Applied Chemistry. **22**: 53. 1912.

Attention is called to the desirability of expressing temperatures on the thermodynamic scale and a table of corrections to the various gas scales is given. It is shown that the platinum resistance thermometer may be used to reproduce the temperature scale with the greatest exactness rom $-200°$ to $+1100°$C. The limitations of thermoelectric and radiation pyrometry are discussed as well as the status (with tables) of several of the boiling and melting points of substances suitable for standard temperatures. International agreement on a temperature scale is urged. The status of the scale may be illustrated by the accompanying tables of standard temperatures.

STANDARD TEMPERATURES. THERMODYNAMIC SCALE

SUBSTANCE	PHENOMENON	TEMPERATURE	UNCERTAINTY	REPRODUCIBILITY
		°C.	°C.	°C.
Hydrogen	Boiling	−252.7	0.2	0.05
Oxygen	Boiling	−182.9	0.1	0.03
Carbon dioxide	Sublimation in gasolene	−78.34	0.1	0.03
Mercury	Freezing	−37.7	0.1	0.05
Water	Freezing	0	0	0.001
$Na_2SO_4 + 10\,H_2O$	Transformation to anhydrous salt	32.383	0.002	0.001
Water	Boiling	100	0	0.001
Naphthalene	Boiling	271.96	0.02	0.01
Tin	Freezing	231.85	0.1	0.05
Benzophenone	Boiling	305.90	0.05	0.02
Cadmium	Freezing	320.92	0.1	0.03
Lead	Freezing	327.4	0.1	0.05
Zinc	Freezing	419.4	0.1	0.10
Sulphur	Boiling	444.6	0.1	0.03
Antimony	Freezing	630	0.5	0.3
Ag_2—Cu_2	Eutectic freezing	779	1	1
NaCl	Freezing	800	2	1
Silver	Freezing	960.5	1	0.5
Gold	Freezing	1063	2	1
Copper	Freezing	1083	2	1
Palladium	Freezing	1549	10	3
Platinum	Melting	1755	15	5
Alumina	Melting	2000	30	20
Tungsten	Melting	3000	100	25
Carbon arc	Pos. crater	3600	150	50
Sun	Surface	6000	500	100

For the temperatures dependent on atmospheric pressure we have:

Oxygen B. P.	$T = T_{760} + 0.013\ (p - 760)$
Carbon dioxide S. P.	$T = T_{760} + 0.017\ (p - 760)$
Water B. P.	$T = T_{760} + 0.037\ (p - 760)$
Napthalene B. P.	$T = T_{760} + 0.058\ (p - 760)$
Benzophenone B. P.	$T = T_{760} + 0.063\ (p - 760)$
Sulphur B. P.	$T = T_{760} + 0.0912\ (p - 760) - 0.000042\ (p - 760)^2$

As to the chemical purity of the various substances, Mylius has shown[1] that the following metals may easily be had to 0.01 per cent or better: Au, Ag, Pt, Hg, Cu, Sn, Pb, Cd, Zn. Of the boiling substances, benzophenone and oxygen are the only ones to the purity of which special attention need be given. G. K. B.

[1] F. Mylius, Zs. Anorg. Ch. **74**: 407. 1912.

BIO-CHEMISTRY.—*Wild volatile-oil plants and their economic importance.* I. *Black sage,* II. *Wild sage,* III. *Swamp bay.* FRANK RABAK. Bulletin 235, Bureau of Plant Industry, pp. 37, with 6 figs. 1912.

In the general part of this bulletin are described the distribution of wild aromatic plants in the United States. The present production of volatile oils obtained from wild plants native to the United States is discussed in detail. A classification of volatile oils based on their odors and constituents is suggested. Attention is called to the commercial importance of volatile oils. The plant sources and the commercial use of the important substances, camphor, borneol and cineol are thoroly discussed.

The special part of this bulletin consists of the investigation of the volatile oils of black sage, wild sage, and swamp bay.

The oil of the black sage (*Ramona stachyoides* (Benth) Briquet.) was found upon examination to consist essentially of camphor (more than 40 per cent) and cineol (22.5 per cent) with smaller quantities of an alcohol, probably borneol, both free and as an ester, thujone, traces of pinene and terpinene, and traces of combined acetic and formic acids. The constituents of possible commercial importance in the oil are camphor and borneol.

Analysis of the oil of wild sage (*Artemisia frigida* Willd.) showed the presence (1) of borneol, 43 per cent, of which about 6.8 per cent exists as bornyl heptoate, leaving 35.8 per cent of free borneol; (2) of cineol (eucalyptol) 18 to 20 per cent; (3) of fenchone 8 to 10 per cent; (4) of free acids, chiefly oenanthylic or heptoic acid, 0.58 per cent, with traces of formic and caprylic acids; (5) of combined acids in the form of esters, chiefly oenanthylic acid, with smaller quantities of valerianic, undecylic and formic acids. The chief constituents of commercial importance are borneol and cineol.

The oil of swamp bay (*Persea pubescens,* (Pursh.) Sarg.) was found to consist chiefly of 21 per cent of camphor, 19.8 per cent of cineol, and borneol, the latter occurring to small extent as esters and as free alcohol. Small quantities of butyric acid and esters of butyric, valerianic and heptoic acids were also present.

The plants which yield the above oils are found in widely separated regions of the United States, in California, South Dakota, and Florida, respectively.

The large quantities of camphor in the oils of black sage and swamp bay are new sources of this important substance. Likewise the large percentage of borneol in the oil of wild sage opens new possibilities.

F. R.

BOTANY.—*The cotton of the Hopi Indians: A new species of Gossypium.* FREDERICK L. LEWTON. Smithsonian Miscellaneous Collections **60**: no. 6, with 5 plates. October 23, 1912.

The early Spanish explorers discovered in 1540 the region now occupied by the pueblo Indians and recorded the cultivation of the cotton plant by the Indians. That the cliff-dwellers, the ancestors of these pueblo Indians of our Southwest, cultivated, spun and wove cotton, has been shown by the work of several eminent ethnologists. Fragments of cotton fabrics are common in the villages of the cliff-dwellers which were in ruins when first seen by the white man.

After tracing the history of cotton cultivation by the Indians of this region and its use by them for ceremonial and household purposes, a technical description of the cotton now grown by the Hopi Indians is given and published as a new species under the name *Gossypium hopi*.

This cotton is conspicuously different from the American upland cottons in color of foliage, flowers, habit of branching, etc., and it is believed that it has never been cultivated by the white man or had any influence in the development of the types of cotton so largely cultivated in the East and South.

The Department of Agriculture has experimented with the Hopi cotton for several years and the experiments show this cotton to be remarkable for its earliness and its ability to grow under very dry conditions.

Owing to the ease with which machine-made cotton yarn can be procured by the Indians from the traders, but very little Hopi cotton is now grown by them, and the smallness of its bolls and poor yield of fiber have not made its cultivation attractive to the white man.

F. L. L.

BOTANY.—*Rubelzul cotton: A new species of Gossypium from Guatemala.* FREDERICK L. LEWTON. Smithsonian Miscellaneous Collections **60**: no. 4, with 2 plates. October 21, 1912.

Gossypium irenaeum is described. This is a shrubby species cultivated by the Kekchi Indians at Rubelzul, a part of the finca "Trece Aguas," a few miles from the town of Senahu in Alta Verapaz, Guatemala. It is planted about the door-yards and yields longer and finer fiber than the species commonly planted by the Kekchi Indians in regular patches, oftentimes at some distance from their dwellings. The most prominent character of this new species is seen in the remarkable development of the calyx, which reaches proportions not known in any other species of Gossypium.

F. L. L.

BOTANY.—*Kokia: A new genus of Hawaiian trees.* FREDERICK L. LEWTON. Smithsonian Miscellaneous Collections **60**: no. 5, with 5 plates. October 22, 1912.

The new genus includes three species, *Kokia drynarioides*, *K. lanceolata*, and *K. rockii*, the last two species being described as new. The genus is based upon a study of herbarium material representing *Gossypium drynarioides* Seemann, from the Island of Molokai, Hillebrand's variety of Seemann's species, from the Island of Oahu, and specimens of a hitherto undescribed species collected in 1909 by Mr. J. F. Rock, of Honolulu, on the slopes of the Volcano Hualalai, Island of Hawaii. *Kokia drynarioides* and *K. lanceolata* are believed to have entirely disappeared from the Hawaiian Islands, and the third species, *K. rockii*, has been reduced to a single group of four trees. These are about 25 feet high, averaging 10 to 12 inches in diameter. F. L. L.

PLANT PHYSIOLOGY.—*A preliminary study of the forced curing of lemons as practiced in California.* ARTHUR F. SIEVERS and RODNEY H. TRUE, Bureau of Plant Industry. Bulletin 232. Feb., 1912.

The process of forced curing of lemons in vogue in California consists in subjecting the green fruit to heat and humidity in tight rooms until the desired color is produced. The time required to accomplish the result ranges from 5 to 14 days.

Experiments are described showing that heat and humidity are of secondary importance in the process and that the pungent, gaseous combustion products from the oil-burning stoves used produce the desired effect. It is suggested that these gases could be used on a commercial scale by generating them in separate structures from which they could be distributed to the different rooms containing the fruit. Such conduction of the gases by means of pipes was found by experiment not to impair their effectiveness.

The loss of stems from the fruit has been a common result of the forced curing process. It has generally been held that the high humidity which obtains in the curing rooms was the cause of this trouble. The experiments here reported prove that the same factor which effects the coloring, also causes the loss of the stems.

A study of the different materials used in the construction of curing rooms relative to their effect on the coloring brought out the fact that material of a porous nature hastens the process. This would indicate

that better results would be obtained in rooms constructed of earth, bricks, or concrete than in rooms of wooden or metal construction.

R. H. T.

PLANT PHYSIOLOGY.—*Absorption and excretion of salts by roots, as influenced by concentration and composition of culture solutions. I. Concentration relations of dilute solutions of calcium and magnesium nitrate to pea roots.* R. H. TRUE and H. H. BARTLETT. Bulletin 231, Bureau of Plant Industry, U. S. Department of Agriculture. Issued January 30, 1912.

Secondary roots of the pea will not develop in $m/5000$ Mg $(NO_3)_2$. A calcium to magnesium ratio of 1/10 is the lowest ratio at which calcium entirely inhibits the harmful effect of magnesium in solutions of this concentration. In solutions of such concentration that magnesium alone would not prevent the formation of secondary roots (e. g., $m/20{,}000$) the calcium to magnesium ratio which brings about perfect root development is nearer 1/100. In solutions of whatever concentration the calcium to magnesium ratio most favorable to absorption of salts is 1/1.

For calcium nitrate solution used as a culture medium, or for magnesium nitrate solution, or for mixtures of the two in any ratio, there is a definite concentration above which roots absorb more electrolytes than they excrete and below which they excrete more thany they absorb. This equilibrium concentration is 12 $m/500{,}000$ for Mg $(NO_3)_2$ and 7 $m/50{,}000$ for Ca $(NO_3)_2$. For solutions of the two in the lowest ratio which permits perfect root development (Ca: Mg: : 1 : 10) the equilibrium concentration is 8 $m/500{,}000$, almost as low as for $Ca(NO_3)_2$ alone. For solutions mixed in the most favorable ratio for absorption (*i. e.*, 5/5) the equilibrium concentration is 5 $m/500{,}000$, lower than for $Ca(NO_3)_2$ alone.

H. H. B.

PHYTOPATHOLOGY.—*The history and cause of the coconut bud-rot.* JOHN R. JOHNSTON. Bulletin No. 228, Bureau of Plant Industry, U. S. Department of Agriculture. Pp. 175, pls. 14 and figs. 10. February, 1912.

Bud-rot is a disease of coconuts which has been known for more than thirty years in Cuba, causing widespread loss. A similar trouble has existed for years in Jamaica, British Honduras, Trinidad, and British Guiana. It is reported also in British India, German East Africa, Portuguese East Africa, the Philippines, and Ceylon.

The disease was investigated in 1901, at the request of the planters of Baracoa, Cuba, by Mr. August Busch, entomologist of the U. S. Department of Agriculture. In 1904, Dr. Erwin F. Smith, plant pathologist of the same Department made further investigations in the districts around Baracoa, and declared the disease to be a bacterial soft rot of the terminal bud. Since that time it has been studied by a number of botanists and mycologists. Investigations were begun by the author of this bulletin in 1907 (in Cuba, Jamaica, Trinidad, and British Guiana), and continued until 1911.

Signs of bud-rot in its incipiency are (1) the falling of the immature nuts; (2) a staining of the opening flower spikes, partly or wholly, to a rich chocolate brown; and (3) the dying and bending over of the middle undeveloped leaves.

The cause of bud-rot has been attributed to soil or climatic conditions, insects, mechanical injuries, etc. Dr. Ramos, of Havana, believed it to be due to a fungus, *Uredo coccivoro*. Dr. Davalos, also of Havana, attributed it to what he claimed to be *Bacillus amylobacter*, which he isolated in 1886. Dr. Plaxton, of Jamaica, exhibited in 1891, slides of a micrococcus which he thought was probably the cause.

Believing the disease to be a bacterial one investigations were continued along the lines planned by Dr. Smith. Material from many diseased trees was obtained, and bacterial organisms were isolated from these tissues, which consisted in general of two types: One which produced, usually, round, wet-shining, white and semiopaque colonies with raised surfaces, and one (type most abundant) which produced colonies of very thin growth, spreading rapidly over the plate, often with long radiating branches, this type being also white, wet-shining, and semitransparent.

In the course of the work such a close similarity of the coconut organism with *Bacillus coli* was observed that comparison of the two organisms was made which shows them to be practically identical. Many special test reactions for the identification of *Bacillus coli* were used not only in characterizing the coconut organism, but also in ascertaining any differences that there might be between it and *Bacillus coli* from animal sources, e.g., behavior in fermentation tubes, growth on Dolt's synthetic medium, reaction to neutral red in various media, D. Rivas' tests, growth on Endo's fuchsin agar, Stoddard's plate medium, Hiss's tube medium (both of the latter used to distinguish *B. coli* from *B. typhosus*), etc.

Special inoculations for the comparison of the coconut organism with *Bacillus coli* (from animals) were made into coconut seedlings, a solution

of ammonium oxalate being injected into a seedling at the same time as a check. Eighteen days after the injection the material was collected, plates were poured, and in five days pink colonies typical of both the coconut organism and of *B. coli* were formed on their respective plates. Along with the other inoculations just described a second injection of *B. coli* (derived from animals) was made into a coconut seedling, and also another solution of ammonium oxalate. After 47 days there was a good typical soft rot in the seedling inoculated with *B. coli*, but there was no characteristic effect from the ammonium oxalate. From this material *B. coli* was isolated, both by the author and by Miss McCulloch. Six experiments in all were conducted in which many inoculations were made with pure cultures of *Bacillus coli* from animals, a good soft rot being produced in the heart tissues of the coconut crown in most cases—a rot similar to that produced by the inoculations with the coconut organisms which were made at the same time. A full table is given, summarizing the characters of the coconut organisms and of *B. coli*, in which but slight variations are noted. In summing up the comparative study of these organisms, Mr. Johnston says:

In the course of such an extended study on a disease as this has been there naturally occur certain results some of which tend to weaken the case and others to strengthen it. The many successful inoculations and the similarity of the cultures injected and isolated, together with the similarity of many other cultures isolated from diseased coconut material by the writer and earlier by Dr. Smith all tend to strengthen the case. On the other hand, successful inoculations by the writer with cultures of variable appearance rather tend to weaken the argument. These results may be explained by the supposition that other organisms than *Bacillus coli* also produce the bud-rot, or that what passes for *Bacillus coli* includes a group of closely related but not identical organisms.

After the above experiments were conducted it was decided to search directly in the diseased tissues for *B. coli*. Material was obtained from Baracoa, Cuba, transfers being made, under clean conditions, to tubes of Dolt's synthetic medium. Platings were made in Washington, and *B. coli* was present as indicated by the tests. Subsequently more material was obtained with a similar result, *Bacillus coli* being isolated 16 days after the material was collected.

Comparison of the bud-rot caused by *Bacillus coli* with several diseases of the coconut palm ascribed in literature to other causes indicates that several of these diseases are identical with bud-rot. It is not known at present that this bud-rot occurs on other palms than the coconut, but it probably does.

The bacteria thrive only in the meristematic tissues which are little or not at all lignified. Stomatal infections are common on the young tissues.

Birds and insects are believed to be carriers of this disease. It is recommended that badly diseased trees be cut down and burned. All fallen leaves, nuts, etc., should be removed.

ERWIN F. SMITH.

PHYTOPATHOLOGY.—*A knot of citrus trees caused by Sphaeropsis tumefaciens.* FLORENCE HEDGES and L. S. TENNY. Bulletin 247, Bureau of Plant Industry, U. S. Department of Agriculture. Pp. 74, pls. 10 and figs. 8. 1912.

This bulletin describes in detail a new fungous disease of citrus trees. Branches of lime and orange trees affected by the disease were first received from Jamaica, but recently a knot on a lime twig was received from Florida, which very much resembles the Jamaican disease, and is probably the same. From the Jamaican material a fungus, *Sphaeropsis tumefaciens* Hedges, has been isolated which reproduces the knots when sound lime and orange trees are inoculated with pure cultures. Many successful inoculations have been made with reisolations from these artificially produced knots.

The first indication of infection is a slight swelling of the branch. As this increases in size the bark, which at this stage covers the young knot, becomes lighter in color and is noticeably cracked and has a cork-like appearance. Growth under greenhouse conditions in Washington is slow, several to many months being necessary for the production of knots 1 to 3 inches in diameter. As the disease develops, secondary knots form on the main branches and trunk, often extending to the ground, and the death of the entire tree is the ultimate result.

The mycelium of the fungus may occur in any or all of the tissues of the stem, being particularly abundant in the cortex and wood. Large, rapidly-growing knots as a rule contain less mycelium than the smaller slow-growing ones. In young, rapidly-growing tissues of buds growing out of knots the mycelium is confined to the intercellular spaces.

The fungus is easily isolated from the knots, fresh young knots being preferable for this purpose. It has also been isolated from the stem between the knots.

The pycnidia as they have been observed upon the host are subglobose, papillate, very dark brown or black, ostiolate, closely crowded together or solitary, with a cellular peridium, and measure 152 to 224

by 120 to 192 μ. The spores, both on the host and in cultures, are large, colorless or yellowish, oblong or ovoid, rounded at both ends, or subacute, measuring 16 to 32 by 6 to 12 μ, being either long and slender (32 by 8 μ), or broad and short (16 by 8 μ), with intergradings. Some time after the appearance of the pycnidia small, cylindrical, colorless, 1-celled, spore-like bodies, the so-called spermatia, are found both in cultures and on the host. Their germination has not been observed. Chlamydospores have never been observed on the host, but in old cultures on steamed vegetables or fruit, large, thick-walled, intercalary, brown, spore-like bodies are sometimes present in abundance.

Pruning is recommended as a remedy for the disease, and care should be taken to remove the affected limbs well below the lowest knot as the mycelium has been found in the stem 1½ ft. beyond any external indication of its presence. Badly diseased trees should be rooted out and burned to prevent dissemination of the fungous spores.

ERWIN F. SMITH.

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PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

A special meeting of the Anthropological Society of Washington, was held December 3, 1912, at 4.30 p.m. in the new building of the National Museum, Mr. Stetson, the President, in the chair.

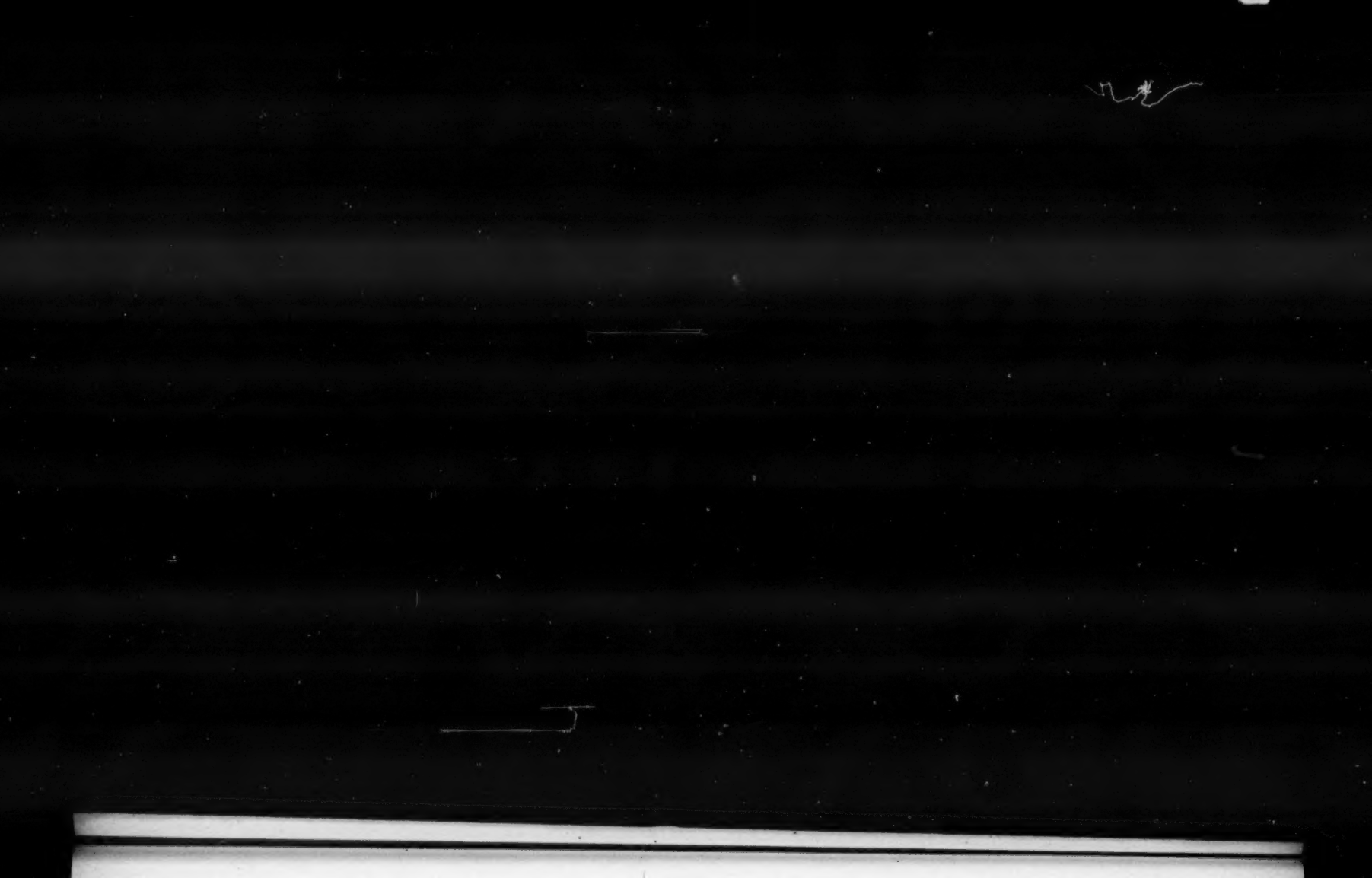
Mr. Wm. H. Babcock read a paper on *The Islands of Antillia* illustrated by lantern-slide maps, taking the title of his paper from Peter Martyr's *Decades of the New World* where that author in view of "the cosmographers," states that he believes these islands were what his contemporary, Columbus, had discovered. Peter Martyr's own sketch map of 1511 was exhibited, showing Florida as one of them under the name of Beineni. There were also displayed the maps of Beccaria, Bianco, Pareto and Benincasa, from 1435 to 1487, who may be among "the cosmographers" referred to. They show a group of four large islands roughly corresponding in size, arrangement and other respects with Cuba, Jamaica, Florida or Beimeni, and Andros or the Bahamas. On Beccaria's map they bear the names Antillia, Reylla, Salvagio and Insula in Mar (Opposite Island or Island out Before, King Island, Savage Island and Island in the Sea). These are nearly as far west of the Azores as the latter are west of Europe and in such a location must be either the creatures of mere fancy or appurtenances of America. But it is not likely that mere guess-work could produce the remarkable correspondences of these great map islands with the reality, such an island group being altogether unique in the Atlantic.

Behaim's globe of 1492 contains an inscription to the effect that a Spanish vessel visited Antillia in 1414. This is more vaguely endorsed by another on the map of Ruysch (1508), which credits the Spaniards with finding Antillia long ago. That something of the kind happened in the first quarter of the fifteenth century may be inferred from the fact that Beccaria (1535) names the group collectively "The Newly Reported Islands," most likely borrowing this title legend from his earlier map of 1426, altho the fourteenth, century maps had contained no suggestion of Antillia and her consorts.

The other fifteenth century maps named corroborate Beccaria, being very consistent in outline and arrangment so far as they go, altho two of them give but three islands and Bianco shows only Antillia and a part of Salvagio, which he calls La Man de Satanaxio, but this last seems to be a case of mutilation. However, the Laon globe of 1493 shows only these two main (rectangular) islands.

A current map showed how naturally any craft entering and continuing in the great-sea-current which sweeps from the Azores and the other eastern islands westward to the Antilles would be carried to Cuba and her neighbors.

The Catalan map of 1375 and the Pizigani map of 1387 with its picture of St. Brandan blessing his Fortunate Islands of Porto Santo and Madeira and the figures of a dragon and a dentapod, each carrying off a seaman from his ship as a warning against westward exploration, were also exhibited. They show the circular island of Brazil west of Ireland and the more southerly crescent-form Man or Brazir, both being important and persistent legendary islands: and the Catalan map in particular shows all the Azores approximately in their real grouping: but neither of them presents anything like the Islands of Antillia.

Dr. PHILIP NEWTON read a paper on the *Negritos of the Philippines*, estimating their total number (full bloods) at 5000, tho by counting mixed blood tribes and individuals the estimate is sometimes carried up to 25,000. They are distributed thru numerous islands, tho not reported from Mindoro. The greater number are on Luzon. There is no difference in them, except as their blood is mingled with that of neighboring races. They are not fishermen, but hunt and gather natural products, using in some districts poisoned arrows, the symptoms of poisoning being like those of strychnine. Their houses are made of upright poles connected by horizontal poles having cross pieces and leaf thatching. Those who die are buried under or near these homes. They rarely bathe and their clothes (which are breech-clouts or aprons), are apparently never washed. Usually these are of cloth obtained in trade, but in some islands, for example Palawan, bark is used. Negritos do not regularly practice agriculture, but will sometimes plant rice—and perhaps move away before it ripens. A skin disease is the most prevalent among them, but malaria also is common. Three incipient cases of tuberculosis were noted and some other diseases have been derived from their neighbors.

WM. H. BABCOCK, *Secretary*.